Revised 5/5/2021

FALSE KILLER WHALE (*Pseudorca crassidens*): Hawaiian Islands Stock Complex – Main Hawaiian Islands Insular, Northwestern Hawaiian Islands, and Hawaii Pelagic Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

False killer whales are found worldwide in tropical and warm-temperate waters (Stacey *et al.* 1994). In the North Pacific, this species is well known from southern Japan, Hawaii, and the eastern tropical Pacific. False killer whales were encountered during three shipboard line-transect surveys of the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands in 2002, 2010, and 2017 (Figure 1; Barlow 2006, Bradford *et al.* 2014, Yano *et al.* 2018) and focused studies near the main and Northwestern Hawaiian Islands indicate that false killer whales occur in near shore waters throughout the Hawaiian archipelago (Baird *et al.* 2008, 2013). This species also occurs in U.S. EEZ waters around Palmyra and Johnston Atolls (e.g., Barlow *et al.* 2008) and American Samoa (Johnston *et al.* 2008, Oleson 2009).

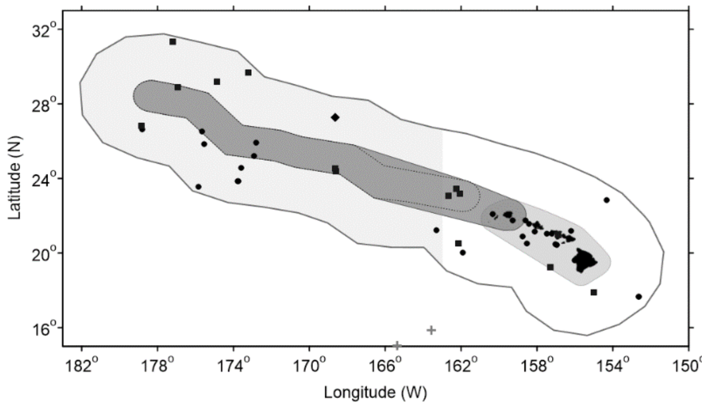

Figure 1. False killer whale sighting locations during the 2002 (diamond), 2010 (circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2014, Yano *et al.* 2018). Medium gray shaded area is the main Hawaiian Islands insular false killer whale stock area., including overlap zone between MHI insular and pelagic false killer whale stocks; Dark shaded gray area is the Northwestern Hawaiian Islands stock area, which overlaps the pelagic false killer whale stock area and part of the MHI insular false killer whale stock area. Outer line represents approximate boundary of survey area and U.S. EEZ. Dotted line represents the original boundary of the Papahanaumokuakea Marine National Monument and the light gray shaded area is the 2016 Expansion area. Detail of stock boundaries shown in Figure 2.

Genetic, photo-identification, and telemetry studies indicate there are three demographically-independent populations of false killer whales in Hawaiian waters. Genetic analyses indicate restricted gene flow between false killer whales sampled near the main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), and in pelagic waters of the Eastern (ENP) and Central North Pacific (CNP) (Chivers *et al.* 2010; Martien 2014). Martien *et al.* (2014) analyzed mitochondrial DNA (mtDNA) control region sequences and genotypes from 16 nuclear DNA (nuDNA) microsatellite loci from 206 individuals from the MHI, NWHI, and offshore waters of the CNP and ENP and showed highly significant differentiation between populations confirming limited gene flow in both sexes. The mtDNA analysis reveals strong phylogeographic patterns consistent with local evolution of haplotypes unique to false killer whales occurring nearshore within the Hawaiian Archipelago, while the nuDNA analysis suggests NWHI false killer whales are at least as differentiated from MHI animals as they are from offshore animals. Photo-ID and social network analyses of individuals seen near the MHI indicate a tight social network with no connections to false killer whales seen near the NWHI or offshore waters, and satellite telemetry collected from 27 tagged MHI false killer whales shows movements restricted to the MHI (Baird *et al.* 2010, 2012). Further analysis of photographic and genetic data from individuals seen near the MHI suggests the occurrence of three separate social clusters (Baird *et al.* 2012, Martien *et al.* 2019). Parentage analysis of sampled individuals reveals natal group fidelity of males and females and mating within the natal group 36-64% of the time (Martien *et al*. 2019). Additional scientific support for the separation of false killer

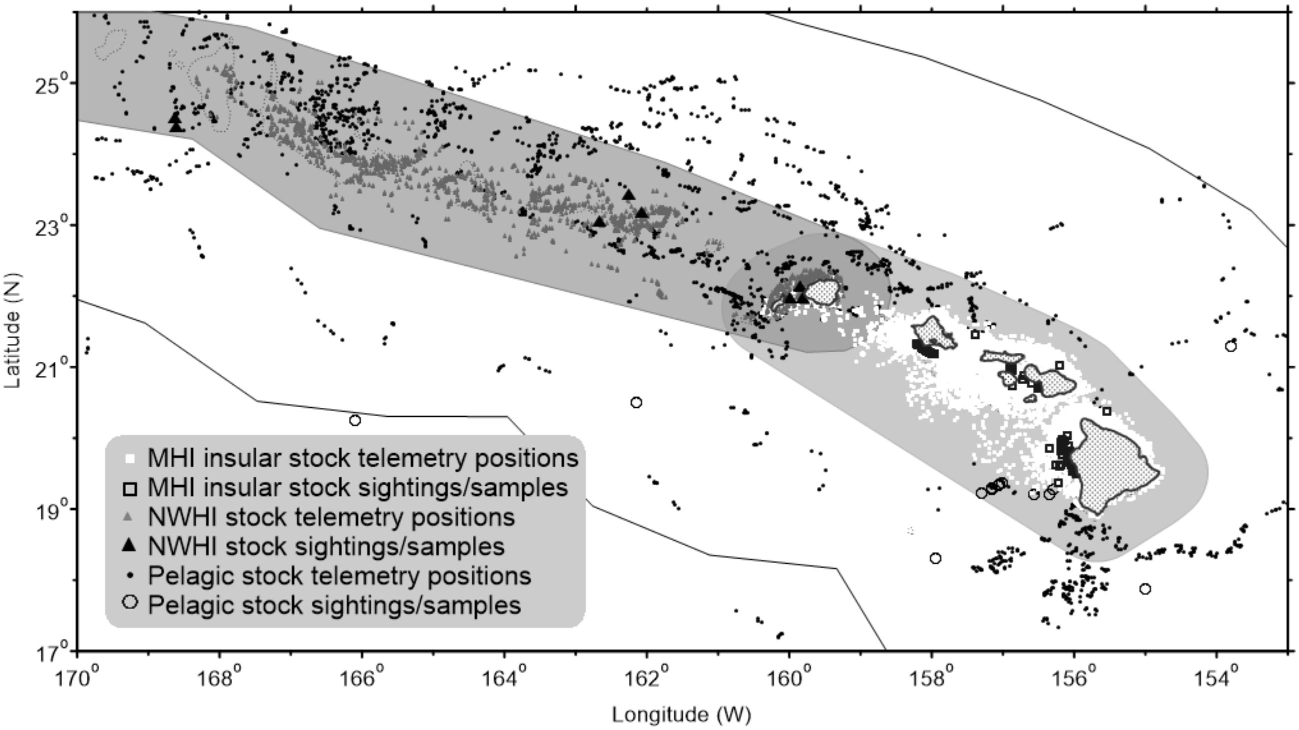

Figure 2. Sighting, biopsy sample, and telemetry record locations of false killer whale identified as being part of the MHI insular (square symbols), NWHI (triangle symbols), or pelagic (circle symbols) stocks. The MHI stock area is shown in light gray; the NWHI stock area is shown in dark gray; the pelagic stock area includes the entire EEZ (reproduced from Bradford *et al.* 2015, with pelagic stock boundary revision described in Bradford *et al*. 2020). The MHI insular, pelagic, and NWHI stocks overlap around Kauai and Niihau.

whales in Hawaiian waters into three separate stocks is summarized by Oleson *et al.* (2010, 2012).

Fishery observers have collected tissue samples for genetic analysis from cetaceans incidentally caught in the Hawaii-based longline fishery since 2003. Between 2003 and 2010, eight false killer whale samples, four collected outside the Hawaiian EEZ and four collected within the EEZ, but more than 100 nautical miles (185km) from the main Hawaiian Islands were determined to have Pacific pelagic haplotypes (Chivers *et al.* 2010). At the broadest scale, significant differences in both mtDNA and nuDNA are evident between pelagic false killer whales in the ENP and CNP strata (Chivers *et al.* 2010). Sample distribution east and west of Hawaiian waters is insufficient to determine whether the sampled strata represent one or more stocks, and where pelagic stock boundaries may occur.

The stock range and boundaries of the three Hawaiian stocks of false killer whales are reviewed in detail in Bradford *et al.* (2015), and further revised for the pelagic stock in Bradford *et al* (2020) (Figure 2). The stocks have partially overlapping ranges. MHI insular false killer whales have been satellite tracked as far as 115 km from the main Hawaiian Islands, while pelagic stock animals have been tracked to within 5.6 km of the main Hawaiian Islands and throughout the NWHI. NWHI false killer whales have been seen up to 93 km from the NWHI and near-shore around Kauai and Oahu (Baird *et al.* 2012, Bradford *et al.* 2015). Stock boundary descriptions are complex, but can be summarized as follows. The MHI insular stock boundary is derived from a Minimum Convex Polygon (MCP) bounded around a 72-km radius of the MHI, resulting in a boundary shape that reflects greater offshore use in the leeward portion of the MHI. The NWHI stock boundary is defined by a 93-km radius around the NWHI, with this radial boundary extended to the southeast to encompass Kauai and Niihau. The NWHI boundary is latitudinally expanded at the eastern end of the NWHI to encompass animal movements observed outside of the 93-km radius (see Figure 2). The pelagic stock has no inner or outer boundary within the EEZ. The 2015 boundary revision placed an inner boundary at 11km from shore around each of the MHI, though this boundary was removed, given new telemetry data indicating use of waters within 5.6 km the MHI (Bradford *et al*. 2020) The construction of these stock boundaries results in multiple stock overlap zones. The entirety of the MHI insular stock area is an overlap zone between the MHI insular and pelagic stocks. The entirety of the NWHI stock range is an overlap zone between NWHI and pelagic false killer whales. All three stocks overlap out to the MHI insular stock boundary between Kauai and Nihoa and to the NWHI stock boundary between Kauai and Oahu (see Figure 2).

The pelagic stock includes animals found within the U.S EEZ around Hawaii and in adjacent international waters. New model-based abundance estimates for the central Pacific enable examination of the status of the broader population of false killer whales relative to human-caused impacts resulting from U.S. fisheries operating in international waters. The Palmyra Atoll stock of false killer whales is still considered to be a separate stock because comparisons amongst false killer whales sampled at Palmyra Atoll and those sampled from the MHI insular stock and the pelagic ENP reveal restricted gene flow, although the sample size remains too low for robust comparisons (Chivers *et al.* 2010). The status of Hawaii pelagic stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005), and abundance estimates for the broader central Pacific (including Palmyra Atoll) are provided for comparison to U.S. fisheries impacts on the high-seas.

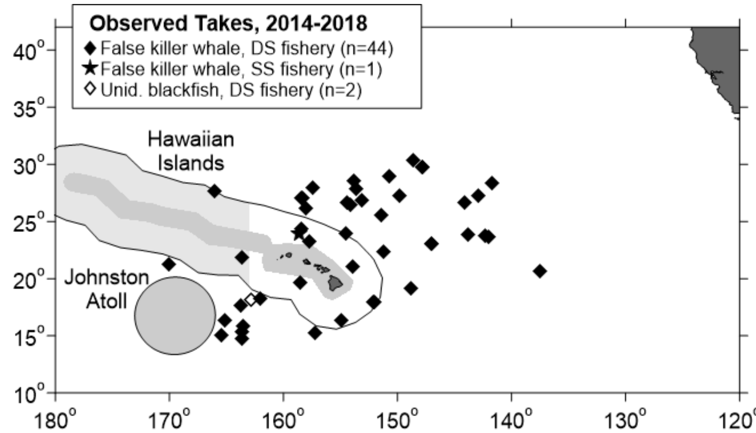

Figure 3. Locations of observed false killer whale takes (black symbols) and possible takes (blackfish) of this species (open symbols) in the Hawaii-based longline fisheries, 2014-2018. Some take locations overlap. Stock boundaries for false killer whales are not shown and all observed takes during this period occurred in the pelagic stock area. Solid lines represent the U. S. EEZ. Gray shading notes areas closed to commercial fishing, with the PMNM Expansion area closed since August 2016**.** Takes within the PMNM closed area occurred prior to the closure in 2016.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are five Pacific Islands Region management stocks: 1) the Main Hawaiian Islands insular stock, which includes animals inhabiting waters within a modified 72 km radius around the main Hawaiian Islands, 2) the Northwestern Hawaiian Islands stock, which includes animals inhabiting waters within a 93 km radius around the NWHI and Kauai, with a latitudinal expansion of this area at the eastern end of the range, 3) the Hawaii pelagic stock, which includes false killer whales inhabiting waters of the U.S. EEZ around Hawaii and adjacent high seas waters, 4) the Palmyra Atoll stock, which includes animals found within the U.S. EEZ of Palmyra Atoll, and 5) the American Samoa stock, which includes animals found within the U.S. EEZ of American Samoa. Estimates of abundance, potential biological removal, and status determinations for the first three stocks are presented below. Palmyra Atoll and American Samoa stocks appear in separate reports.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Interactions with false killer whales, including depredation of pelagic fish catch, have been identified in logbooks and NMFS observer records from Hawaii pelagic longline fishing trips (Nitta and Henderson 1993, Oleson *et al.* 2010, PIRO 2015). False killer whales have been observed feeding on a variety of large pelagic fish, including mahi mahi (*Coryphaena hippurus)*, yellowfin tuna (*Thunnus albacares),* big eye tuna (*T. obesus*), albacore *(T.alalunga),* wahoo (*Acanthocybium solandri*), skipjack (*Katsuwonus pelamis*), and broadbill swordfish (*Xiphias gladius*) (Baird 2016), and they are reported to take large fish from trolling lines of commercial and recreational fishermen (Shallenberger 1981). There are anecdotal reports of marine mammal interactions in the commercial Hawaii shortline fishery which sets gear at Cross Seamount and possibly around the main Hawaiian Islands. The commercial shortline fishery is licensed to sell catch through the State of Hawaii Commercial Marine License program, and until recently, no reporting systems existed to document marine mammal interactions. Baird and Gorgone (2005) documented high rates of dorsal fin disfigurements consistent with injuries from unidentified fishing line for MHI insular stock false killer whales. Evaluation of additional individuals with dorsal fin injuries and disfigurements suggests that the interaction rate between false killer whales and various forms of hook and line gear may vary by population and social cluster, with the highest rates in the MHI insular stock (Baird *et al.* 2014). The commercial or recreational fishery or fisheries responsible for these injuries is unknown. A stranded MHI insular false killer whale in October 2013 had five fishing hooks and fishing line in its stomach and another stranded animal in September 2016 had one fishing hook in its stomach (Bradford and Lyman *et al*. 2018). Although the fishing gear is not believed to have caused the death of either whale, examinations confirm that MHI insular false killer whales consume previously hooked fish or are interacting with MHI hook and line fisheries. Many of the hooks within the whale's stomach were not consistent with those currently allowed for use within the commercial longline fisheries and could have come from a variety of near-shore fisheries. No estimates of human-caused mortality or serious injury are currently available for near-shore hook and line or other fisheries because these fisheries are not monitored for protected species bycatch.

Because of high rates of false killer whale mortality and serious injury in Hawaii-based longline fisheries, a Take Reduction Team was established in January 2010 (75 FR 2853, 19 January, 2010). The Team was charged with developing recommendations to reduce incidental mortality and serious injury of the Hawaii pelagic, MHI insular and Palmyra stocks of false killer whales in Hawaii-based longline fisheries. The Team submitted a draft Take Reduction Plan (TRP) to NMFS, and NMFS published a final TRP based on the Team's recommendations (77 FR 71260, 29 November, 2012). Take reduction measures include gear requirements, time-area closures (the Southern Exclusion Zone, or SEZ), and measures to improve captain and crew response to hooked and entangled false killer whales. The seasonal contraction of the Longline Exclusion Zone (LLEZ) around the MHI was also eliminated. The TRP became effective December 31, 2012, with gear requirements effective February 27, 2013. Adjustments to bycatch estimation methods were implemented for 2013 to account for changes in fishing gear and captain training intended to reduce the false killer whale serious injury rate (McCracken 2015).

There are two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas, but are prohibited from operating within the Papahānaumokuākea Marine National Monument (PMNM) and within the LLEZ around the main Hawaiian Islands and the Pacific Remote Islands and Atolls (PRIA) MNM around Johnston Atoll. The PMNM originally included the waters within a 50 nmi radius around the NWHI. As of August, 2016, the PMNM area was expanded to extend to the 200 nmi EEZ boundary west of 163º W. Between 2014 and 2018, one false killer whale were observed hooked or entangled in the SSLL fishery (100% observer coverage) within the U.S. EEZ of the Hawaiian Islands, and 44 false killer whales were observed taken in the DSLL fishery (18-21% observer coverage) within Hawaiian waters or adjacent high-seas waters (Bradford 2018a, 2018b, 2020, Bradford and Forney 2017) (Figure 3). The severity of injuries resulting from interactions with longline gear is determined based on an evaluation of the observer's description of each interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). The one animal taken in the SSLL fishery was considered not seriously injured. In the DSLL fishery, 9 false killer whales were taken within the Hawaiian EEZ, all within the range of the pelagic stock, with 7 considered seriously injured, one non-seriously injured, and one could not be determined based on the information provided by the observer. Outside of the Hawaii EEZ three were observed dead, 24 were considered seriously injured, six were considered not seriously injured, and two could not be determined based on the information provided by the observer. One additional unidentified "blackfish" (unidentified cetaceans known to be either false killer whales or short-finned pilot whales) were also taken within in the DSLL fishery outside of the Hawaii EEZ and was considered seriously injured. The SEZ, a large triggered closure area south of the MHI implemented under the TRP, was closed following 2 serious injuries within the Hawaii EEZ in November 2018. This closure remained in effect through the remainder of calendar year 2018.

The total estimated number of dead or seriously injured whales is calculated based on the ratio of observed dead and seriously injured whales versus those judged to be not seriously injured. Prior to the implementation of the FKW TRP, for the period 2008 to 2012, the rate of dead and seriously injured false killer whales was 93% (McCracken 2014). The implementation of weak hooks under the TRP was intended to reduce the serious injury rate in the deep-set fishery, and as such the proportion of dead and seriously injured whales versus non-serious injuries is calculated annually based on the injury status of observed takes since the implementation of the TRP in 2013 (McCracken 2019).

The pelagic stock interacts with longline fisheries based on two genetic samples obtained by fishery observers (Chivers *et al.* 2010). MHI insular and NWHI false killer whales have been documented via telemetry to move far enough offshore to reach longline fishing areas (Bradford *et al.* 2015), and MHI insular stock animals have high rates of dorsal fin disfigurements consistent with injuries from unidentified fishing line (Baird and Gorgone 2005, Baird *et al.* 2014). Annual bycatch estimates are prorated to stock using the following process. Takes of unidentified blackfish are prorated to false killer whale and short-finned pilot whale based on distance from shore (McCracken 2010) given patterns of previous bycatch for each species. Following proration of unidentified blackfish takes to species, Hawaii EEZ and high-seas estimates of false killer whale take are calculated by summing the annual false killer whale take and the annual blackfish take prorated as false killer whale within each region (McCracken 2019). Takes within the shallow-set longline fishery are assigned to the stock area in which they were observed. Estimated takes in the deep-set fishery within the Hawaii EEZ are apportioned to each stock area by first allocating take to each areas based on relative annual fishing effort (by set) in that area. If an observed take occurred within the MHI-pelagic or NWHI-pelagic overlap zones, the take was assigned to that zone and the remaining estimated bycatch was assigned to stock areas as previously described. For both the shallow-set and deep-set fisheries, stock area bycatch estimates are then multiplied by the relative density of each stock within the stock area to estimate stock-specific bycatch for each year.

Uncertainty in stock-specific bycatch estimates combines variances of total annual false killer whale bycatch and the fractional variance of false killer whale density according to which stock is being estimated. Enumeration of fishing effort within stock overlap zones is assumed to be known without error.

Based on this approach, estimates of annual mortality and serious injury of false killer whales, by stock and EEZ area are shown in Table 1. Two mortality and serious injury estimates are provided: a 5-yr average for the period prior to TRP-implementation (2008-2012), and a 5-yr average for the most recent 5 years following the TRP (2014-2018). The bycatch rate (per 1000 sets) and the proportion of non-serious injuries prior to and following TRP implementation are examined for all stocks as part of the FKW TRT monitoring strategy.

Table 1. Summary of available information on incidental mortality and serious injury (MSI) of false killer whales and unidentified blackfish (false killer whale or short-finned pilot whale) in commercial longline fisheries, by stock and EEZ area, as applicable (McCracken 2019). 5-yr mean annual takes are presented for 2008-2012 (prior to the implementation of the TRP) and for 2014-2018. Information on observed takes (T) and combined mortality and serious injury is included. Unidentified blackfish are pro-rated as either false killer whales or short-finned pilot whales based on distance from shore (McCracken 2010). CVs are estimated based on the combined variances of annual false killer whale and blackfish take estimates and the relative density estimates for each stock within the overlap zones. Values of '0' presented with no further precision are based on observation at 100% coverage and are not estimates.

				Observed takes		**Estimated M&SI (CV)**			
				FKW T/MSI UB T/MSI		**Pelagic Stock**			
Fishery Name	**Year**	**Data Type**	**Percent Observer Coverage**	**Outside U.S EEZ**	**Within Hawaii EEZ**	**Outside U.S EEZ**	**Within Hawaii EEZ**	**MHI insular Stock**	**NWHI Stock**
Hawaii-based deep-set longline fishery	2014	Observer data	21%	9/8 0	2/1† 0	35.8 (0.5)	8.4 (0.7)	0.0 (0.8)	0.0 (1.5)
	2015		21%	5/4 1/1†	0 0	22.3 (0.4)	0 (-)	0 (-)	0 (-)
	2016		20%	9/8† 0	1/1 0	27.9 (0.3)	4.0 (0.8)	0 (0.8)	0 (2.1)
	2017		20%	4/4† 0	2/1 0	28.5 (0.4)	8.1 (0.6)	0.1 (0.6)	0 (2.0)
	2018		18%	8/5 0	4/4 0	29.7 (0.4)	11.9 (0.4)	0.1 (0.5)	0 (2.0)
Pre-TRP Mean Estimated Annual Take (CV) 2008-2012						**10.0 (0.4)**	**13.3 (0.2)**	**0.2 (0.4)**	**0.6 (0.8)**
Mean Estimated Annual Take (CV) 2014-2018						**28.8 (0.2)**	**6.5 (0.3)**	**0.03 (0.3)**	**0.01 (1.1)**
Hawaii-based shallow-set longline fishery	2014	Observer data	100%	0 0	1/0 0	0.2	0	0	0
	2015		100%	0 0	0 0	0	0	0	0
	2016		100%	0 0	0 0	0	0	0	0
	2017		100%	0 0	0 0	0	0	0	0
	2018		100%	0 0	0 0	0	0	0	0
Pre-TRT Mean Annual Takes (100% coverage) 2008-2012						**0.3**	**0.3**	**0**	**0**
Mean Annual Takes (100% coverage) 2014-2018						**0.2**	**0**	**0**	**0**
Pre-TRP Minimum total annual takes within U.S. EEZ (2008-2012)							**13.6 (0.2)**	**0.2 (0.4)**	**0.6 (0.8)**
Minimum total annual takes within U.S EEZ (2014-2018)							**6.5 (0.3)**	**0.03 (0.3)**	**0.01 (1.1)**

† Injury status could not be determined based on information collected by the observer. Injury status is prorated (see text).

Proration of false killer whale and unidentified blackfish takes within overlap zones introduces unquantified uncertainty into the bycatch estimates. Until methods of determining stock identity and/or species (e.g. photos, tissue samples) for animals observed taken within the overlap zone are available, proration approaches are needed ensure that potential impacts to all stocks are assessed in the overlap zones.

MAIN HAWAIIAN ISLANDS INSULAR STOCK

POPULATION SIZE

Bradford *et al.* 2018 used encounter data from dedicated and opportunistic surveys for MHI insular false killer whales from 2000 to 2015 to generate annual mark-recapture estimates of abundance. Due to spatiotemporal biases imposed by sampling constraints, annual estimates reflect the abundance of MHI insular false killer whales within the surveyed area in that year, and therefore should not be considered indicative of total population size every year. The abundance estimate for 2015 was 167 (CV = 0.14). Annual estimates over the 16 year survey period ranged from 144 to 187 animals and are similar to multi-year aggregated estimates published previously (Oleson *et al.* 2010).

Minimum Population Estimate

The minimum population estimate for the MHI insular stock of false killer whales is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2015 abundance estimate (from Bradford *et al.* 2018), or 149 false killer whales.

Current Population Trend

Reeves *et al.* (2009) suggested that the MHI insular stock of false killer whales may have declined between 1989 and 2007, based on sightings data collected near Hawaii using various methods. Baird (2009) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the main Hawaiian Islands between 1994 and 2003 (Mobley *et al.* 2000). Sighting rates during these surveys showed a statistically significant decline that could not be attributed to any weather or methodological changes. The Status Review of MHI insular false killer whales (Oleson *et al.* 2010) presented a quantitative analysis of extinction risk using a Population Viability Analysis (PVA). The modeling exercise was conducted to evaluate the probability of actual or near extinction, defined as a population reduced to fewer than 20 animals, given measured, estimated, or inferred information on population size and trends, and varying impacts of catastrophes, environmental stochasticity and Allee effects. All plausible models indicated the probability of decline to fewer than 20 animals within 75 years was greater than 20%. Though causation was not evaluated, all plausible models indicated the population had declined since 1989, at an average rate of -9% per year (95% probability intervals -5% to -12.5%), though some two-stage models suggested a lower rate of decline (Oleson *et al.* 2010). Annual abundance estimates in Bradford *et al.* 2018 are not appropriate for evaluating population trends, as the study area varied by year, and each annual estimate represents only animals present in the study area within each year.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the MHI insular false killer whale stock is calculated as the minimum population estimate (149) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.1 (for a stock listed as Endangered under the ESA and with minimum population size less than 1500 individuals; Taylor *et al.* 2000) resulting in a PBR of 0.3 false killer whales per year, or approximately one animal every 3.3 years.

STATUS OF STOCK

The status of MHI insular stock false killer whales relative to OSP is unknown, although this stock appears to have declined during the past two decades (Oleson *et al.* 2010, Reeves *et al.* 2009; Baird 2009). MHI insular false killer whales are listed as “endangered” under the Endangered Species Act (1973) (77 FR 70915, 28 November, 2012). The Status Review report produced by the Biological Review Team (BRT) (Oleson *et al.* 2010, amended in Oleson *et al.* 2012) found that Hawaiian insular false killer whales are a Distinct Population Segment (DPS) of the global false killer whale taxon. Of the 29 identified threats to the population, the BRT considered the effects of small population size, including inbreeding depression and Allee effects, exposure to environmental contaminants (Ylitalo *et al.* 2009), competition for food with commercial fisheries (Boggs & Ito, 1993, Reeves *et al.* 2009), and hooking, entanglement, or intentional harm by fishermen to be the most substantial threats to the population. Because MHI insular false killer whales are formally listed as "endangered" under the ESA, they are automatically considered as a "depleted" and "strategic" stock under the MMPA. For the 5-yr period prior to the implementation of the TRP, the average estimated mortality and serious injury to MHI insular stock false killer whales (0.21 animals per year) exceeded the PBR (0.18 animals per year. Following implementation of the TRP a significant portion of the recognized stock range is inside of the expanded year-round LLEZ around the MHI, providing significant protection for this stock from longline fishing. Prior to that time, a seasonal contraction to the LLEZ potentially exposed a significant portion of the offshore range of the stock to longline fishing. For the most recent 5-yr period, the estimate of mortality and serious injury (0.03) is below the PBR (0.30). The total fishery mortality and serious injury for the MHI insular stock of false killer whales cannot be considered to be insignificant and approaching zero, as it is ≥ 10% of PBR. Effects of other threats have yet to be assessed, e.g., nearshore hook and line fishing and environmental contamination. There is significant geographic overlap between various nearshore fisheries and evidence of interactions with hook-and-line gear (e.g. Baird *et al.* 2015), such that these fisheries may pose a threat to the stock. Five MHI insular false killer whales stranded between 2010-2016, including four from cluster 3 (PIRO MMRN), a high rate for a single social cluster. Recent research has indicated that concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz *et al.* 2014).

HAWAII PELAGIC STOCK

POPULATION SIZE

Encounter data from shipboard line-transect surveys conducted throughout the central Pacific were used to estimate the abundance of false killer whales across the central Pacific, including within the Hawaii EEZ (Bradford *et al*. 2020; Table 2).

Table 2. Model-based line-transect abundance estimates for false killer whales derived from NMFS surveys in the central Pacific since 1997 (Bradford *et al*. 2020).

	Hawaii EEZ			Central Pacific		
Year	Model-based abundance	CV	95% Confidence Limits	Model-based abundance	CV	95% Confidence Limits
2017	2,086	0.35	1,079-4,031	34,536	0.35	17,782-54,363
2010	2,144	0.32	1,159-3,965	25,212	0.33	13,449-47,262
2002	2,122	0.33	1,136-3,964	25,723	0.30	14,397-45,958

The model-based abundance estimates use sighting data from 1997 to 2017 from across the central Pacific to derive habitat-based models of animal density for the overall period. The models were then used to predict the density and abundance for each Hawaii survey year (2002, 2010, and 2017) based on the environmental conditions within that year (see Forney *et al*. 2015, Becker *et al*. 2016). The modeling framework incorporates Beaufort-specific trackline detection probabilities for false killer whales derived following the methods of Barlow *et al*. (2015) and accounts for changes in false killer whale data collection through time (see Bradford *et al*. 2020 for details). Bradford *et al*. (2020) also produced design-based abundance estimates for false killer whales within each survey year and these can be used as a point of comparison to the model-based estimates. While on average, the estimates are broadly similar between the two approaches, the annual design-based estimates show much greater variability between years than do the model-based estimates (Figure 4). The model-based approach reduces variability through

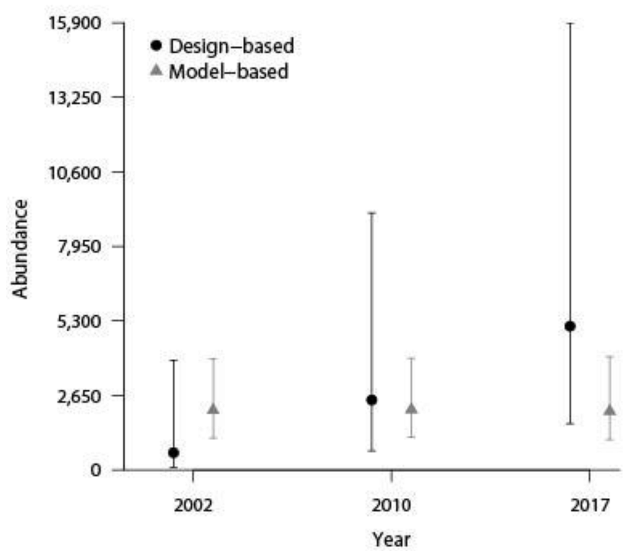

Figure 4. Comparison of design-based (circles) and model-based (triangles) (Bradford *et al*. 2020) estimates of abundance for false killer whales for each survey year (2002, 2010, 2017).

explicit examination of habitat relationships across the full dataset, while the design-based approach evaluates encounter data for each year separately and thus is more susceptible to the effects of encounter rate variation. Bradford *et al*. (2020) found through simulation that the low sighting rate in 2002 and high sighting rate in 2017 could be explained by encounter rate variation. Although a 'year' covariate was tested during model development, it was not selected as a significant variable. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are considered the best available estimate for each survey year. Current model-based estimates for the central Pacific include animals that are considered part of the Palmyra Atoll stock, as well as animals that may be part of an eastern Pacific stock on the eastern edge of the modeled area, and therefore are likely an overestimate of the full Hawaii pelagic stock abundance. Previous abundance estimates from the Hawaii EEZ and central Pacific using subsets of the full dataset and different line-transect parameters have been published previously. The estimate of 2,086 (CV=0.35) from the 2017 survey is considered the best available current estimate for false killer whales in the Hawaii EEZ (Bradford *et al*. 2020).

The reanalysis may still be subject to potential bias due to vessel attraction as described by Bradford *et al.* (2014). There the authors reported that most (64%) false killer whale groups seen during the 2010 survey were seen moving toward the vessel when detected by the visual observers. Together with an increase in sightings close to the trackline, these behavioral data suggest vessel attraction is likely occurring and may be significant. Similar to the treatment of the detection function in Bradford *et al.* (2014, 2015), new model-based estimates use Beaufort-specific effective strip width estimates (following Barlow *et al*. 2015) derived from an analysis that used a half-normal model to minimize the effect of vessel attraction. The abundance estimate may still be positively biased due to vessel attraction because groups originally outside of the survey strip, and therefore unavailable for observation by the visual survey team, may have moved within the survey strip and been sighted. The acoustic data and visual data suggests vessel attraction (Bradford *et al.* 2014), though the extent of any bias created by this movement is unknown.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017 abundance estimate for the Hawaiian Islands EEZ (Bradford *et al.* 2020) or 1,567 false killer whales. For the entire central Pacific study area, the minimum population size for 2017 is estimated to be 25,940 false killer whales.

Current Population Trend

Although a 'year' covariate was evaluated during model development and not included during the model selection process, the final model-based abundance estimates for false killer whales provided by Bradford *et al.* (2020) do not explicitly examine population trend other than that driven by environmental factors. In contrast, annual design-based estimates suggest an increase population size within the Hawaii EEZ, however, these changes can be largely explained by random variability in encounter rate common for species with low density and patchy distribution. Examination of population trend for false killer whales requires additional data inside and outside of the Hawaii EEZ.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii pelagic stock of false killer whales is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (1,567) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with a Hawaiian Islands EEZ mortality and serious injury rate CV <= 0.30; Wade and Angliss 1997), resulting in a PBR of 16 false killer whales per year. For the entire central Pacific, based on the minimum population size of 25,940 false killer whales, and using the same recovery factor and maximum net growth rate as for the Hawaii pelagic stock, would yield a PBR of 259 false killer whales per year.

STATUS OF STOCK

The status of the Hawaii pelagic stock of false killer whales relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz *et al.* 2014), and elevated concentrations are also expected in pelagic false killer whales given the amplification of these contaminants through the food chain and likely similarity in false killer whale diet across the region. This stock is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Following the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005), the status of this transboundary stock of false killer whales is assessed based on the estimated abundance and mortality and serious injury within the U.S. EEZ of the Hawaiian Islands because estimates of human-caused mortality and serious injury from all U.S. and non-U.S. sources in high seas waters are not available. The estimated mortality and serious injury within the Hawaii EEZ in 2018 was the highest recorded since before the TRP was put into place. Although take estimates for 2019 are not reported here, 5 observed takes within the EEZ were reported in that year, resulting in closure of the SEZ in February 2019. Take rates of false killer whales by the deep-set longline fishery outside of the EEZ continue to remain significantly higher since the TRP. Model-based estimates of abundance and PBR for the central Pacific should be considered when evaluating stock status across the fishery area. Total 5-year mortality and serious injury for 2014-2018 (6.5) is less than PBR (16), therefore this stock is not considered a "strategic stock" under the MMPA. Additional monitoring of bycatch rates of this stock are required before assessing whether TRP measures have reduced rangewide fishery takes below PBR. Total fishery mortality and serious injury for the Hawaii pelagic stock of false killer whales cannot be considered to be insignificant and approaching zero.

NORTHWESTERN HAWAIIAN ISLANDS STOCK

POPULATION SIZE

Encounter data from shipboard line-transect surveys of the entire Hawaiian Islands EEZ were reevaluated for each survey year, resulting in the following abundance estimates of Northwestern Hawaiian Islands false killer whales (Bradford *et al*. 2020; Table 3).

Table 3. Line-transect abundance estimates for Northwestern Hawaiian Islands false killer whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al*. 2020).

Year	Abundance	CV	95% Confidence Limits
2017	477	1.71	48-4,712
2010	878	1.15	145-5,329
2002	N/A		

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for false killer whales following the methods of Barlow *et al*. (2015). Although a previous 2010 estimate for this stock was published using a subset of this data, Bradford *et al*. (2020), uses a consistent approach for estimating all abundance parameters and resulting estimates are considered the best available. There were no sightings of false killer whales in the NWHI stock area in 2002. The reanalysis may still be subject to potential bias due to vessel attraction as described by Bradford *et al.* (2014). Those authors reported that most (64%) false killer whale groups seen during the 2010 HICEAS survey were seen moving toward the vessel when detected by the visual observers. Together with an increase in sightings close to the trackline, these behavioral data suggest vessel attraction is likely occurring and may be significant. Bradford *et al.* (2014, 2015, 2020) used a half-normal model to minimize the effect of vessel attraction, because groups originally outside of the survey strip, and therefore unavailable for observation by the visual survey team, may have moved within the survey strip and been sighted. There is some suggestion of such attractive movement within the acoustic and visual data (Bradford *et al.* 2014) though the extent of any bias created by this movement is unknown. The best estimate of current abundance is 477 (CV=1.71) false killer whales from the 2017 survey (Bradford *et al*. 2020).

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017 abundance estimate for the Northwestern Hawaiian Islands stock (Bradford *et al.* 2020) or 178 false killer whales. This estimate has not been corrected for vessel attraction and may be positively-biased.

Current Population Trend

The two available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding evaluation of population trend for this stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in the waters surrounding the Northwestern Hawaiian Islands.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Northwestern Hawaiian Islands false killer whale stock is calculated as the minimum population estimate (178) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.40 (for a stock of unknown status, with a Hawaiian Islands EEZ mortality and serious injury rate CV > 0.8; Wade and Angliss 1997), resulting in a PBR of 1.4 false killer whales per year.

STATUS OF STOCK

The status of false killer whales in Northwestern Hawaiian Islands waters relative to OSP is unknown, and insufficient data exists to evaluate abundance trends. Concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz *et al.* 2014), and elevated concentrations are expected in NWHI false killer whales given amplification of these contaminants through the food chain and likely similarity in false killer whale diet across the region. Biomass of some false killer whale prey species may have declined around the Northwestern Hawaiian Islands (Oleson *et al.* 2010, Boggs & Ito 1993, Reeves *et al.* 2009), though waters within the original Papahānaumokuākea Marine National Monument have been closed to commercial longlining since 1991 and to other fishing since 2006. This stock is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. The rate of mortality and serious injury to NWHI false killer whales (0.01) is less than the PBR (1.4 animals per year), and can be considered to be insignificant and approaching zero. A very small portion of the recognized stock range lies outside of the newly expanded PMNM and the expanded LLEZ, such that this stock is likely not exposed to high levels of fishing effort because commercial and recreational fishing is prohibited within Monument waters and longlines are excluded from the majority of the stock range.

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